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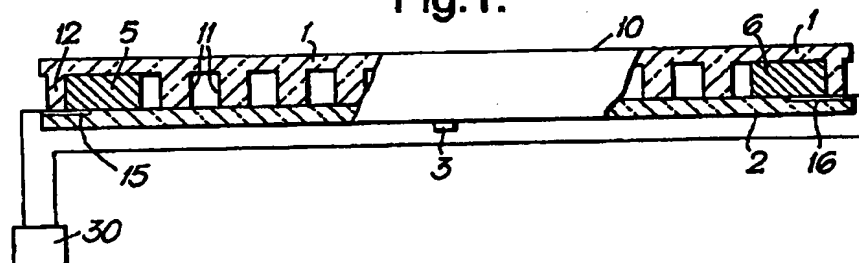
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(54) Discharge lamp

(57) A planar discharge lamp is made by photo-etching a plate 1 e.g. of silicon to form an array of pillars 11 within a peripheral wall 12. A second plate 2 e.g. of borosilicate glass bonded on top of the plate 1 e.g. electrostatically. Internal surfaces of the lamp are coated with a dielectric UV-reflective layer (20) and with a fluorescent layer (21). The lamp is evacuated and filled with a discharge gas including a buffer gas and mercury vapour, and is suitable for back-lighting instruments or other displays.

Fig.1.



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Fig. 1.

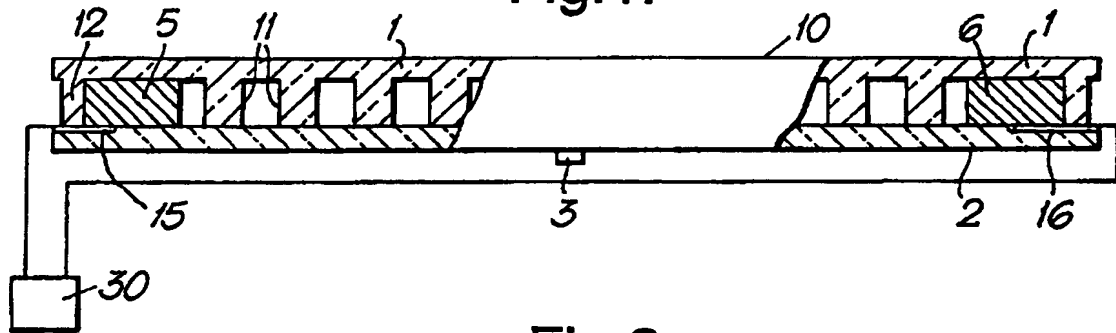


Fig. 2.

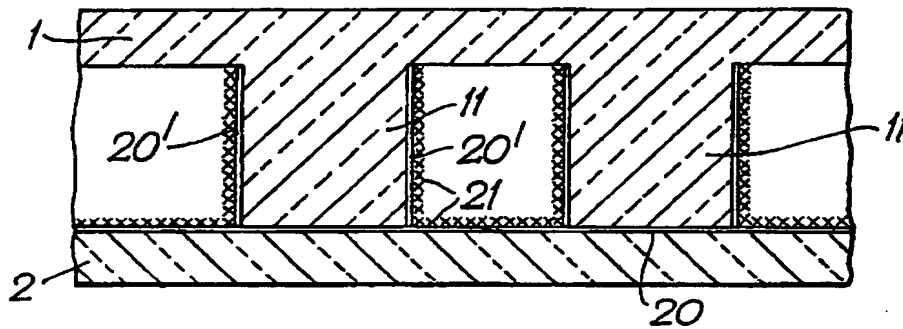
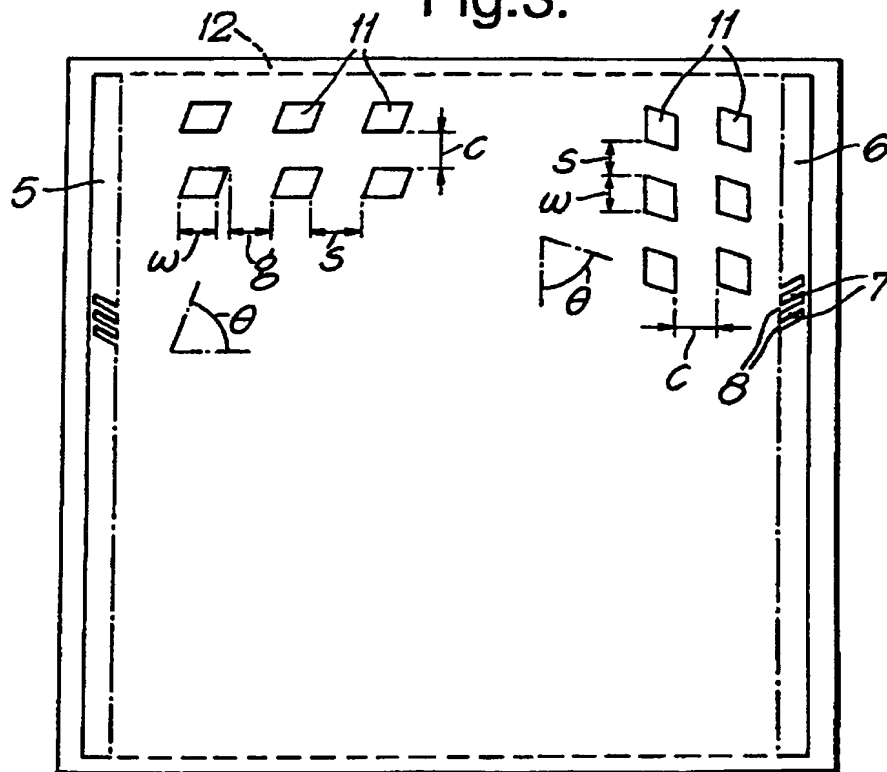


Fig. 3.



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PLANAR LAMPS AND METHODS OF MANUFACTURE

This invention relates to planar lamps and methods of manufacture of such lamps.

The invention is more particularly concerned with planar discharge lamps such as used for back-lighting instruments or other displays.

A planar discharge lamps can be a compact light source with an even illumination over its surface. These lamps have two transparent, glass plates enclosing a volume of discharge gas at reduced pressure. The low pressure within the lamp can lead to deformation of the plates unless they are made very thick or some form of internal support is provided. In order to keep weight and size to a minimum, it is generally preferred to use relatively thin plates and to support these internally. Examples of lamps, including an array of internal pillars to support the plates, are shown in WO 90/00075, GB 2244855, GB 2247563, GB 2247977, GB 2254724, GB 2261320, GB 2274191 and GB 2269700.

In these arrangements, the pillars are formed from the same material as the plates and are produced by mechanically machining away parts of a surface of one or both plates. This machining process adds considerably to the cost of the lamp.

It is an object of the present invention to provide an improved planar lamp and a method of making such a lamp.

According to one aspect of the present invention there is provided a method of making a planar lamp comprising the steps of providing a first plate with a surface of a first material, photo-etching the surface of the plate to remove regions of the plate such as to leave an array of pillars within a peripheral wall of the first material, and bonding a second plate on the first

plate so that the second plate is supported on the first plate by the pillars and the wall, evacuating the lamp and filling it with a discharge gas at reduced pressure.

The method may include the step of applying a fluorescent layer to internal wall surfaces of the lamp. The method may include the step of applying a UV-reflective layer, which is preferably of a dielectric material, to internal wall surfaces of the lamp. The second plate is preferably bonded to the first plate by electrostatic bonding. The method may include the step of depositing a metal layer on vertical wall surfaces of the pillars. A perforated mask may be placed over the pillars during the step of depositing the metal layer. The first material is preferably silicon. The second plate is preferably of a borosilicate glass. The method may include the step of filling the lamp with a buffer gas and a mercury vapour.

According to another aspect of the present invention there is provided a lamp made by the method of the above one aspect of the invention.

According to a further aspect of the present invention there is provided a planar lamp including two plates at least one of which is transparent, one of said plates being photo-etched on one surface into an array of pillars within a peripheral wall, the space between the plates and the pillars being filled with a discharge gas at reduced pressure, and the lamp having two electrodes at opposite sides of the plate arranged to cause discharge within the lamp.

The one plate is preferably of silicon and the other of the plates is preferably of a borosilicate glass.

A fluorescent discharge lamp according to the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional elevation view of the lamp;

Figure 2 shows a part of Figure 1 to a greater scale;
and

Figure 3 is a plan view of the lamp illustrating
two different layouts of pillars.

The lamp is square, being 88mm by 88mm and with a thickness of 2.5mm. The lamp comprises an upper plate 1 of silicon and a lower plate 2 of a borosilicate glass, which may be doped with cerium oxide to render it stable under electron and UV radiation. This glass is of a kind produced by Pilkington PE Ltd - Space Technology under the name CMZ. The glass material has a thermal expansion closely matched to that of silicon and is described in EP0261885 and US5017521. The lower plate 2 is flat and uninterrupted on both sides except for a short glass pump port 3 projecting centrally from its lower surface and two buried deposited conductors 15 and 16 extending across the width of the plate on its upper surface at opposite ends. The lower plate is 0.5mm thick.

The upper plate 1 is of silicon with a flat uninterrupted upper surface 10 and a thickness of 2.0mm. The lower surface of the silicon plate 1 is photoetched to remove regions of the plate and leave an array of vertical pillars 11 with a peripheral wall 12. The pillars 11 and the wall 12 are 1.5mm high, making the upper part of the plate 1, above the pillars, 0.5mm thick. The pillars 11 are preferably lozenge-shape in section, as shown in Figure 3, with a width w of 1mm. The pillars 11 are arranged in rows with one pair of sides of each pillar aligned with one another along the row. In the left-hand of Figure 3, the pillars 11 are shown arranged in rows extending along the length of the lamp; in the right-hand of the Figure, the rows extend across the lamp. In both arrangements, the spacing c between the rows is equal to the width of the pillars, that is, it is 1mm, and the acute angle θ of the walls of the pillars to one another is 71° . The spacing s between adjacent pillars is 1.35mm so that the gap g between the most forward edge on one pillar and the rearmost edge of the adjacent pillar is equal to the width (1mm) of the pillars. At each end of the lamp, within the wall 12, there is a comb-shape electrode 5 and 6

made from a sheet of alloy such as Kovar. The electrodes 5 and 6 each have a row of alternate teeth 7 and slots 8 inclined at an angle of 30° to the normal to the length of the electrodes. Connection to the electrodes 5 and 6 is made by means of the conductors 15 and 16.

The lower plate 2 has a dielectric coating 20 reflective of light in the UV part of the spectrum. The coating 20 extends across the floor area of the lower plate 1 and beneath the pillars 11. An aluminium layer 20', 1-2 μ m thick, is coated on the vertical wall surfaces of the pillars 11 by deposition. A perforated metal mask (not shown) is placed on the underside of the plate 1 against the lower surface of the plate between the pillars 11 to prevent the metal coating being deposited on this surface. The mask is removed after the layer 20' has been formed. The upper plate 1 may also have a UV-reflective dielectric coating extending across its lower surface between the pillars although this may be omitted because of the difficulty of depositing a thin dielectric layer on a surface populated with pillars. On top of the reflective coatings 20 and 20' there is a phosphor layer 21, which is fluorescent at one or more of the wavelengths of radiation produced by discharge within the lamp. The phosphor layer 21 covers that part of the floor area of the lower plate 1 not occupied by the pillars 11 and also extends up the vertical sides of the pillars. There is no phosphor layer on the lower surface of the upper plate 1.

The lamp is evacuated to low pressure and contains a mercury discharge vapour.

In operation, a high alternating voltage is applied across the electrodes 5 and 6 from a power source 30 to cause cold-cathode discharge within the lamp. The discharge produces visible radiation and UV radiation. The UV radiation produces fluorescence of the phosphor 21 to increase the intensity of visible radiation. The reflective coatings 20 and 20' reflect any UV radiation passing through the phosphor 21 back through the phosphor and into the discharge space, to increase further the amount of visible radiation produced. Visible radiation produced directly by the discharge, by reflection from the internal surfaces, or by fluorescence, emerges from the lamp through the upper plate 1, which is transparent to visible radiation.

The lamp is manufactured by photoetching a flat silicon wafer to the required depth to produce the peripheral wall 12 and the pillars 11 in the upper plate 1. The dielectric coating 20 is then formed on the upper surface of the lower plate 2. The coating 20 may be multi-layer coatings of alternate quarter-wavelength layers of sapphire. Instead of sapphire, which is an oxide of aluminium, oxides of dysprosium, scandium or tantalum could be used. The reflective coating has an upper layer of silica, less than one quarter of a wavelength thick.

The phosphor layers 21 are then deposited on the upper and lower plates 1 and 2, and the conductors 15 and 16 are deposited at the edges of the lower plate, which may be a multi-layer alloy of Ti:Pd:Ag deposited to a depth of 10 microns.

The upper and lower plates 1 and 2 are then bonded together electrostatically by raising the temperature of the assembly to between 400° and 500°C and applying pulses of electrostatic energy across the glass-silicon interface. This induces ion migration into the upper silica layer in the coating 20 and results in strong ionic bonding between the two materials. The underlying CMZ glass and silicon materials have closely matched thermal characteristics so there is little differential thermal expansion on thermal cycling.

This produces an enclosed envelope that is subsequently evacuated through the exhaust port 3 in the lower plate 2. The envelope is then filled with a buffer gas, such as argon, and with mercury vapour at low pressure; the port is then sealed closed. This completes the lamp. Alternatively, prior to electrostatic bonding, a number of getter/dispenser rings, such as those manufactured by SAES Getters Ltd, may be placed around several of the pillars 11. The getter rings contain a total of about 2-3mg of mercury in the form of a titanium-mercury alloy and 30mg of a zirconium based alloy, which forms the sorbing (non-evaporable) getter material. After the envelope has been filled with the buffer gas and the port 20 sealed, the rings are activated by RF heating using a hand-held coil suitably focussed. This activation liberates mercury and causes the sorbing getter to commence operation. This provides a long-term

absorption of the small quantities of impurities that leech out of the lamp structure during its life.

Because the pillars 11 supporting the plates 1 and 2 are produced by photo-etching, this avoids previous expensive machining processes. Assembly and sealing of the two plates is also facilitated.

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CLAIMS

1. A method of making a planar lamp comprising the steps of providing a first plate with a surface of a first material, photo-etching said surface of the plate to remove regions of the plate such as to leave an array of pillars within a peripheral wall of the first material, and bonding a second plate on the first plate so that the second plate is supported on the first plate by the pillars and the wall, evacuating the lamp and filling it with a discharge gas at reduced pressure.
2. A method according to Claim 1, wherein the method includes the step of applying a fluorescent layer to internal wall surfaces of the lamp.
3. A method according to Claim 1 or 2, including the step of applying a UV-reflective layer to internal wall surfaces of the lamp.
4. A method according to Claim 3, wherein the UV-reflective layer is of a dielectric material.
5. A method according to any one of the preceding claims, wherein the second plate is bonded to the first plate by electrostatic bonding.
6. A method according to any one of the preceding claims, wherein the method includes the step of depositing a metal layer on vertical wall surfaces of the pillars.
7. A method according to Claim 6, wherein a perforated mask is placed over the pillars during the step of depositing the metal layer.
8. A method according to any one of the preceding claims, wherein the first material is silicon.

9. A method according to any one of the preceding claims, wherein the second plate is of a borosilicate glass.
10. A method according to any one of the preceding claims, wherein the method includes the step of filling the lamp with a buffer gas and mercury vapour.
11. A method substantially as hereinbefore described with reference to the accompanying drawings.
12. A lamp made by a method according to any one of the preceding claims.
13. A planar lamp including two plates at least one of which is transparent, wherein one of said plates is photo-etched on one surface into an array of pillars within a peripheral wall, wherein the space between the plates and the pillars is filled with a discharge gas at reduced pressure, and wherein the lamp has two electrodes at opposite sides of the plate arranged to cause discharge within the lamp.
14. A lamp according to Claim 13, wherein said one plate is of silicon.
15. A lamp according to Claim 13 or 14, wherein the other of the plates is of a borosilicate glass.
16. A lamp substantially as hereinbefore described with reference to the accompanying drawings.
17. Any novel feature or combination of features as hereinbefore described.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Application number
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Relevant Technical Fields

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- (ii) Int Cl (Ed.6) H01J (9/00, 9/24, 9/26, 61/00, 61/30, 61/35, 61/36, 61/70, 61/72, 61/74)

Search Examiner
M J DIXON

Date of completion of Search
10 JANUARY 1995

Databases (see below)

(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

Documents considered relevant following a search in respect of Claims :-
ALL

(ii) ONLINE: WPI

Categories of documents

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- A: Document indicating technological background and/or state of the art. &: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y	GB 2068357 A	(MODERN CONTROLS) the whole document	1, 2, 9-11, 13, 15
Y	GB 1267327 A	(NATIONAL CASH REGISTER) see eg. Figure 4; page 2, line 106 et seq	1, 2, 9-11, 13, 15
Y	WO 90/09676 A	(SMITHS) see especially page 9, lines 16 to 19	1, 2, 9-11, 13, 15
Y	EP 0467542 A	(SMITHS) see especially column 6, lines 50 to 54	1, 2, 9-11, 13, 15
Y	US 4839555 A	(O'MAHONEY) see column 4, lines 9 to 15	1, 2, 9-11, 13, 15

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